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Odor markers detection system for mobile robot navigation

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Abstract

The paper presents the development of the odor markers detection system for mobile robot navigation along a chemical path. Chemical sensors are relatively slow in comparison with sensors commonly used for mobile robot navigation. To reduce the time parameters of gas sensors, a new method of probe sampling was developed. An active sensory system for robot odor navigation was elaborated. The final results of application of this system on mobile robot was presented.

Keywords: odor path tracking, semiconductor gas sensor, navigation, mobile robot

1. Introduction

The navigation task consists in planning the path of movement and then controlling its realization. Marking in the environment an easily observable path that can be followed by robot is extensively used in industrial transport. This types of robots are called AGV (Automated Guided Vehicle). Painted lines or cables powered by high frequency alternating current are usual solution, but disadvantage of this method is its low flexibility - to change the route one should remove the old lines and paint the new ones.

Short Living Navigational Markers (SLNM), such as odor or heat, give new capabilities in this field. The lines marked in this way disappear after the robot completes its work - similarly like the pheromones paths created by insects [1].

To detect and to follow chemical trails the suitable gas sensors must be used. As possible for use in robotics quartz microbalance sensors [1-2], conducting polymer sensors [3-4], miniaturized photo

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ionization detector (miniPID) [5-6] and semiconductor gas sensors were considered. There was also an interesting attempt of using biological sensor using living moth antennae [7]. It is difficult to determine which kind of sensor is the best for mobile robot navigation [8-9], but semiconductor gas sensor are certainly the cheapest and most readily available.

In the case of commercially available semiconductor gas sensors, the basic problem is their slow reaction for the changes of concentrations of the active chemical (especially long relaxation time), which significantly limits the speed of the movement along the tracked path.

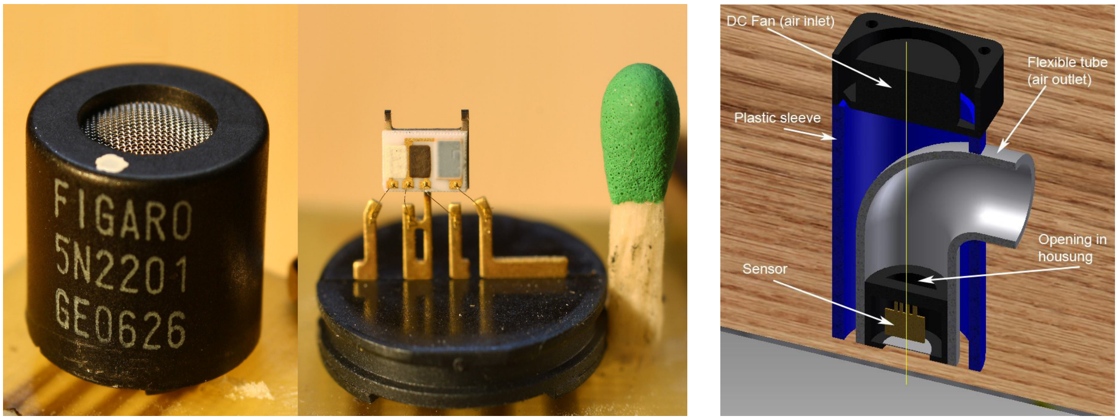
The paper presents the development of the odor path detection system based on modified gas sensors.

2. The developed probe sampling system for semiconductor gas sensor

In conventional applications the most important parameter of chemical sensors is the accuracy of measurement of gas concentration. On the contrary, in mobile robotics applications the key parameters for sensors analyzing the robot environment are [10]:

- sensitivity to tested chemical,
- detection threshold, and
- time of reaction to changes of gas concentration.

An analysis of available gas sensors performed according to features described above led to selection of TGS 2201 device manufactured by Figaro (Fig. 1a).

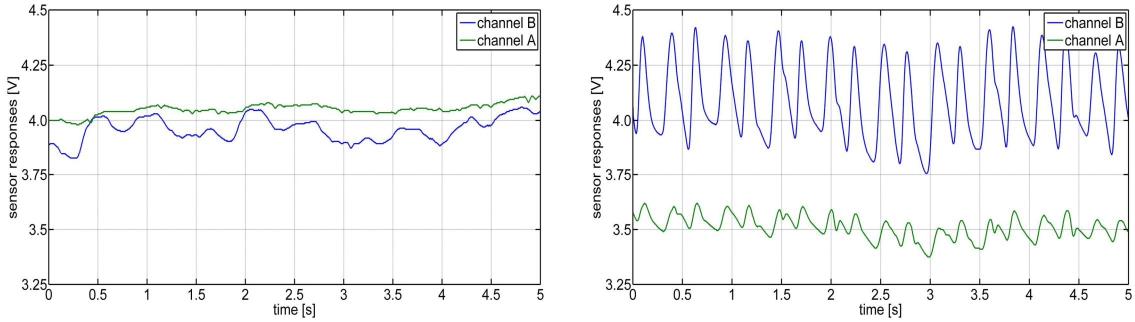


(a) (b)

Fig. 1. (a) TGS2201 Figaro semiconductor gas sensor; (b) Developed probe sampling system

A scheme of developed probe sampling problem solution is shown in Figure 1b. A small fan (25x25 mm) is used to force the airflow. The stream is directed downwards, creating pressure between the sensor and ground. Part of the airflow returns and passes through the perforated sensor housing. The rest of stream is being released to the sides, forming an air curtain blocking molecules from large distances preventing reaching the sensor.

Figure 2 shows strongly improved ability to distinguish a single path crossing in a series. Sensor crosses over the path 4 times per second. When fan is off, distinction between single crossings is impossible. With use of developed sampling system, the distinction is easy, and no path crossing is missing. This improved sensor performance is suitable for use in mobile robot.

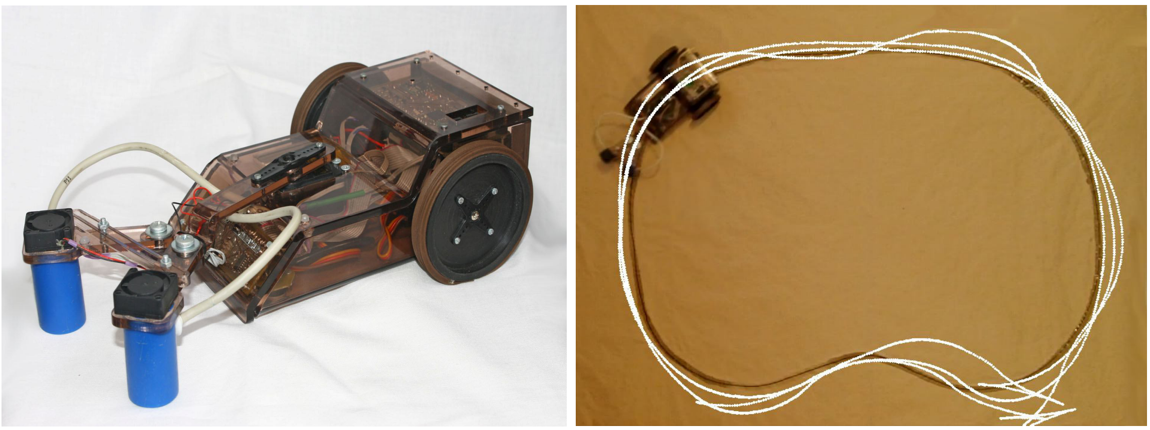


(a) (b)

Fig. 2. Response of modified TGS 2201 sensor for alcohol. Measurements performed for sensor head oscillating above and crossing the smell source line with frequency of 4 Hz. Fan turned off (a) and on (b).

3. The mobile robot tracking odor path

The results of experiments carried out with developed mobile robot (Fig 3 a) equipped with elaborated odor sensor system were shown in Figure 3b. The black line represents the path marked with ethyl alcohol. The white line shows the real trajectory of the robot registered by the video camera (three rides along the path). It was created by bright LED diode placed in the center of the robot. Path tracking speed was up to 10 cm/s. The loss of the track and falling out from the right path may be seen in the bottom right corner. It may be also seen, that the robot can return to the correct track, with the appropriate corrective manoeuvres.



(a) (b)

Fig. 3. (a) The mobile robot with mounted active sensors; (b) Tracking the odor path

4. Conclusions

The creation of dedicated probe sampling system, forcing a controlled gas flow around the active element of the semiconductor sensor TGS2201, to adapt it to the robotics requirements was carried out. The result was significantly better dynamic performance. Based on these active sensors, mobile robot tracking the odor path was developed. The conducted experiments showed that the developed system provides sufficient information for proper odor navigation.

Presented approach encourages further work. Next objectives are:

- search for other options to modify the gas sensor to achieve higher sensitivity;
- experiments with sensory systems organized in the other way;
- search for other volatile substances which ensure certain properties of chemical trace,
- development of sensory system able to distinguish between separate, created concurrently tracks (various chemicals), so that the robot could decide which goal to pursue, (which path to move);
- development of a sensor system capable of evaluation of the concentration gradient in three dimensional space ("odor compass") [11-12].
- development of a sensor system providing active localization of sources of gas emission dedicated for emergency and monitoring systems [13-14].

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